APPENDIX C

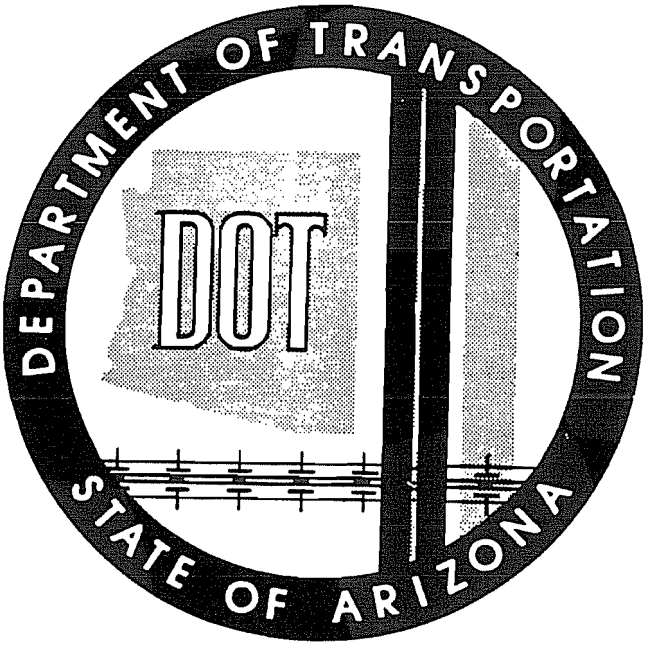
GUIDELINES FOR GEOTECHNICAL INVESTIGATION AND GEOTECHNICAL REPORT PRESENTATION

The following document, dated September 1991 and entitled "Guidelines for Geotechnical Investigation and Geotechnical Report Presentation", has been prepared by Geotechnical Services. The guidelines contained therein are for use on all ADOT related projects. These guidelines supplement the information given in Section 100 of this manual, and contain more comprehensive requirements for subsurface investigations. All geotechnical investigations started after December 31, 1991 will be expected to follow these guidelines and reports will be reviewed accordingly.

GUIDELINES FOR GEOTECHNICAL INVESTIGATION

AND

GEOTECHNICAL REPORT PRESENTATION



GEOTECHNICAL SERVICES, MATERIALS SECTION
ARIZONA DEPARTMENT OF TRANSPORTATION
PHOENIX, ARIZONA

GUIDELINES FOR

GEOTECHNICAL INVESTIGATION

AND

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SEPTEMBER 1991

GEOTECHNICAL SERVICES, MATERIALS SECTION
ARIZONA DEPARTMENT OF TRANSPORTATION
PHOENIX, ARIZONA

INTRODUCTION

These guidelines have been developed primarily as an aid to geotechnical consultants and engineers engaged in working on highway projects for the Arizona Department of Transportation. They are meant to supplement, not supersede, the contract documents or publications mentioned below. In the preparation of these guidelines, material has been taken from and consideration given to the recommendations made in the following publications:

1. American Society for Testing and Materials; 1990 Annual Book of ASTM Standards Vol. 04.08.

2. American Association of State Highway and Transportation Officials, Inc.; Manual on Subsurface Investigations; 1988.

3. American Association of State Highway and Transportation Officials; Standard Specifications for Transportation Materials and Methods of Sampling and Testing; 15th Edition; Part I, Specifications; 1990. (AASHTO Designation R-13-88, pp. 873-877)

4. Arizona Department of Transportation; Materials Preliminary Engineering and Design Manual, Third Edition; March 1989.

5. Federal Highway Administration, U. S. Department of Transportation; Checklist and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications; October 1985.

6. Oregon Department of Transportation Soil and Rock Classification Manual; 1987

Subsurface conditions are often highly varied and complex. Subsurface exploration procedures cannot be reduced to a few guidelines to fit all conditions. Each project must be evaluated according to its specific geologic conditions and the type of proposed facility (AASHTO, 1988). Generally, the subsurface explorations are carried out in two stages:

1. Preliminary Investigation
2. Final Investigation

Please note that the goal is to conduct the geotechnical exploration program in one phase. However, roadway and bridge design processes often require preliminary information before certain items (alignment, grade, foundation location and depth) can be firmly established. Planning and scheduling must be conducted accordingly, and every attempt made to provide the geotechnical information efficiently and effectively.

A preliminary exploration program generally will consist of widely spaced test borings to define the principal geologic parameters to be evaluated during initial project planning and cost estimating. Preliminary information should be obtained and reported regarding the following conditions during early stages of design:

1. Geologic Conditions
2. Hydrologic Conditions
3. Soil Classification, Consistency and Density
4. Rock Quality - Condition and Discontinuities
5. Obstructions (e.g. Boulders)
6. Hazards (e.g. Methane Gas)

A final exploration program will provide specific recommendations. Final alignment, grade and geometry, bridge pier and abutment locations and foundation depths should have been selected prior to completion of the final report. The information obtained from preliminary investigations should be considered a part of the final exploration program.

GENERAL COMMENTS

It is anticipated that the drilling equipment will use sampling devices which yield samples 1.5 inches to 6.0 inches in diameter. For all types of investigation,

1. A boring must not be ended in a soft or loose soil stratum (N<10) or in an unsuitable material. N= number of blows of Standard Penetration Test (ASTM D 1586-84).

2. SPT sampling will be performed at 2, 5, and 10 foot depths where spread footings may be placed on natural soils. Otherwise, SPT sampling will be performed at 5 foot depth intervals or at significant changes in strata, whichever provides the most samples.

3. In rock, continuous core will be obtained for the top 10 foot or to the required depth for structural foundation, whichever is deeper. The percentages of core recovery and RQD will be determined and reported in accordance with ASTM D 2113-83.

4. For groundwater, water levels encountered at the completion of the boring and at least 24 hours after completion will be recorded on boring logs.

The following are the guidelines for determining the MINIMUM number and depths of borings to be made in each case:

I. BRIDGE STRUCTURE

A. Number for preliminary investigation:

1. each isolated structure over a waterway - one boring at each abutment location and one boring as close to the middle of the waterway as possible.

2. each isolated structure not over a waterway - one boring at each abutment location.

3. at each interchange, for all structures - 4 to 6 borings.

B. Number for final investigation (See Fig. 1):

1. one boring per substructure unit (abutment, bent or pier) 100 feet or under in width.

2. two borings for each substructure unit greater than 100 feet in width.

C. Depth

A boring must be advanced into competent material of suitable bearing capacity.

1. in soils - three times the width/diameter of the foundation or a minimum of 20 feet below the base of the spread footing or tip elevation for pile or drilled shaft.

2. in bedrock - a minimum of 10 ft. below the base of the spread footing or tip elevation for pile or drilled shaft.

II. RETAINING WALL

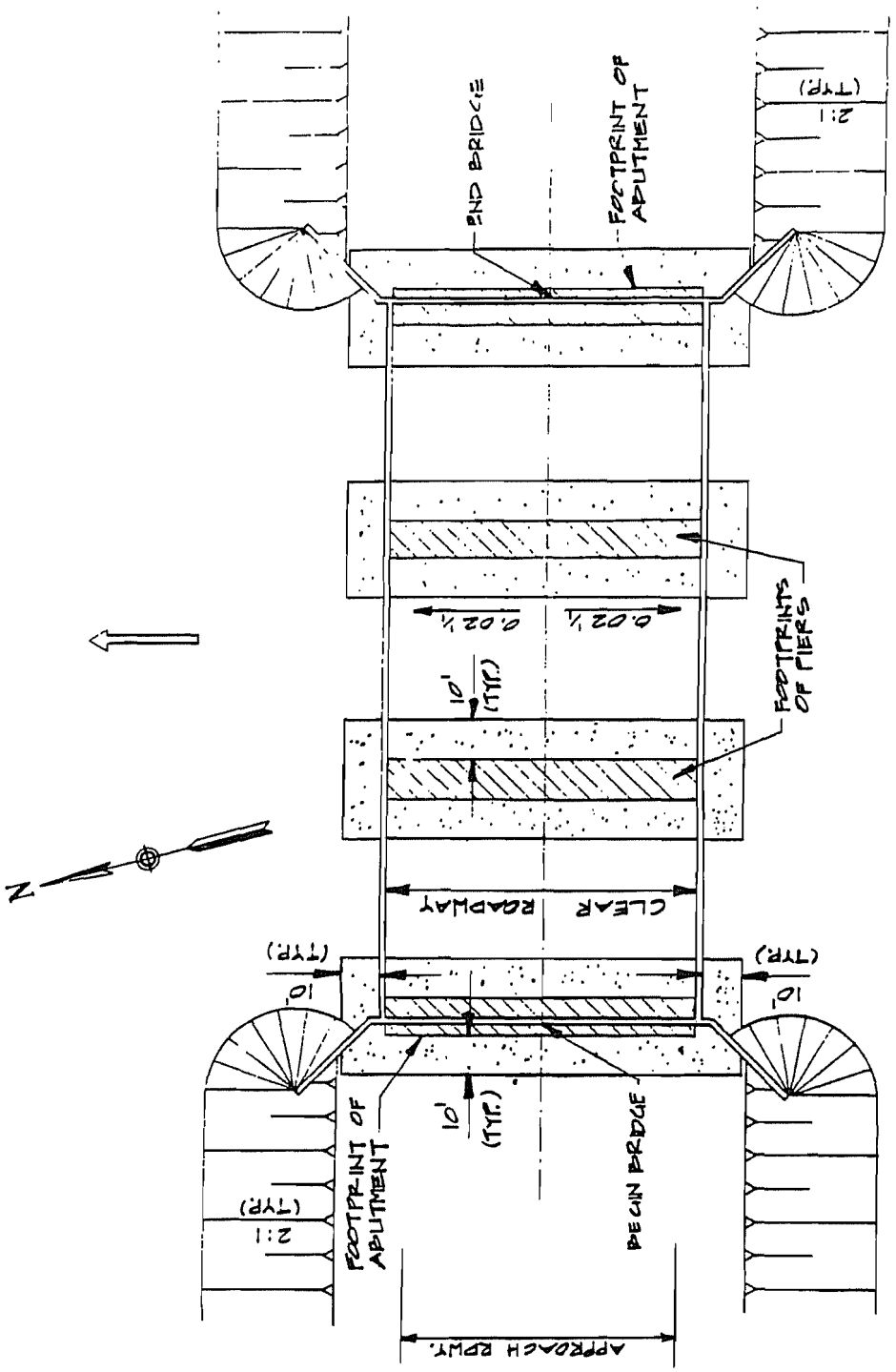
A. Number for preliminary investigation:

one boring for each wall up to 500 feet in length and then one boring for each 500 (±) feet.

B. Number for final investigation:

1. walls less than 100 feet long - one boring

2. walls 100 feet or longer - borings at approximately 150 feet intervals staggered back and front of wall footing.



EXAMPLE OF BORE HOLE LOCATION AREAS FOR BRIDGE STRUCTURES

C. Depth

The depth of boring shall be either

1. two times the height of the wall, or

2. a minimum 10 feet in bedrock

III. CUTS, FILLS AND SUBGRADE

A. Number for preliminary investigation - borings or backhoe pits at 1200 - 1500 feet intervals.

B. Number for final investigation - per ADOT Materials PE&D Manual.

C. Depth for preliminary and final investigation - per ADOT Materials PE&D Manual.

D. R-values and other special test results should be obtained per ADOT Materials PE&D Manual.

IV. CMP

A. Number for preliminary investigation - one boring in each major drainageway, preferably near the mid-length.

B. Number for final investigation - as above.

C. Depth

The minimum depth of borings shall be to 3 feet below the invert elevation.

V. AGGREGATE AND BORROW PITS

A minimum number of 5 backhoe pits or borings will be required for preliminary investigation. Final investigation to follow ADOT PE&D Manual. Samples will be obtained at 5 foot depth intervals or at significant changes in strata, whichever provides the most samples. Enough material will be collected for performing R-value tests, PI tests and grain size analyses of soil.

VI. LOG OF BORING SHEET

The Logs of Borings sheet shall be included as part of the Geotechnical Investigation Report. The location of each boring or test pit in plan view should be shown elsewhere. Logs of all borings shall be shown in an elevation or profile view, each log being on a separate sheet. Information which should be shown on each plot of test borings is as follows:

1. Date, diameter and type of borings.
2. Name of driller and field geologist/engineer.
3. Location of borings with respect to stationing along survey lines and offset from it.
4. Elevation of the top of boring and water table.
5. Results of the Standard Penetration Test (ASTM D-1586-84).
6. Description of stratum material for soils according to ASTM D2487-85 but modified to exclude most of the numerical data obtained from in-situ or laboratory testing.

VII. WRITTEN REPORT

A geotechnical investigation report shall be required of all proposed pavement and structure projects. The study and report shall be made by an Arizona Professional Engineer who specializes in Geotechnical Engineering and who shall seal each report and each plans sheet.

A written report shall contain information, analyses and interpretation of the subsurface conditions based upon all available sources of information and data. Data may come from new or previous exploration programs, laboratory testing, nearby construction experience, performance of nearby existing pavement or structures, etc. A short description of site topography and local geology shall be included. Emphasis should be placed on slope stability of fills, cuts and excavations, unusual groundwater conditions, springs, etc. All sources of information should be cited. The materials and conditions which may be encountered during construction shall also be discussed. Anticipated problems involving design and construction should be mentioned, and recommendations made for their solution.

The recommendations shall be brief, concise, and complete. Reasons for recommendations and supporting data shall be included. Methods and equations of models used for calculating pile or drilled shaft capacities and soil bearing capacities should be mentioned. Data and information which are of no use to the designer or Resident Engineer, should be omitted. Any judgements and opinions regarding the rippability or excavability of rock or soil should not be included; however, if the consultant or engineer feels that these opinions are important to include, they should be reported concisely and shall include a statement that the information is the judgement of the writer and that other interpretations are possible. The same applies to methods for rock or soil removal.

Any recommended geotechnical Special Provisions should be included; these should be developed considering the requirements of ADOT's Standard Specifications, and using these, where appropriate.

The ground compaction, excavation factors (shrink and swell), pH, resistivity and slopes should be provided by stationing. Also, this information should be summarized (in tabular form, if applicable), in the report.

In general, a geotechnical investigation report should contain the following sections:

1. Introduction

2. Project Description: Project Concept and Scope

3. Site Description: Including a vicinity map, site plan and existing pavement conditions and section measurements as necessary.

4. Geologic Description

5. Field Investigation: Including boring location plan and any in-situ testing.

6. Laboratory Investigation: Generally, the tests will include gradation analysis, plasticity index, moisture content, R-value, AASHTO T-99 density, consolidation, pH resistivity, shearing strength of soils and unconfined compressive strength of rocks.

7. Discussion of Information, Analyses and Recommendations

8. Geotechnical Special Provisions

9. References Cited

9. Appendix A

   a. Test drilling equipment and procedure

   b. Terminology used for various descriptions

   c. Explanations of symbols and abbreviations used on boring logs.

   d. Boring Logs in Graphical Form

10. Appendix B

   a. Laboratory Testing Procedures and Standard Test Number (Arizona Test Method, AASHTO Test Method or ASTM Test Method Designations).

   b. Summary of Test Data

   c. Tables and Special Test Data

VIII. MISCELLANEOUS COMMENTS

1. On boring logs, the general descriptive sequence for soils will be as follows:

   Group Name
   Group Symbol
   Moisture Condition
   Color
   Relative Density/Consistency
   Particle Angularity/Plasticity
   Cementation
   Structure
   Other pertinent descriptive information

All descriptions will follow the recommendations of ASTM D-2488-84. For relative density refer to Table 1.

2. On boring logs, the general descriptive sequence for rocks will be as follows:

   Rock Name
   Color
   Degree of Weathering - Refer to Table 2
   Relative Hardness - Refer to Table 3
   Structure
   a. Stratification - Refer to Table 4
   b. Joint and Bedding Spacing - Refer to Table 5
   Other pertinent descriptive information

   Formation Name
   Percent Core Recovery and Rock Quality Designation (RQD) if not already reported elsewhere on the log.

3. On boring logs, the N-value (ASTM D-1586-84) should be reported only in one of the three following ways:

   a. 10 blows/zero inch

   b. N blows/foot, where N is the blow count less than 100.

   c. 50 blows/X inches, where X is the sampler penetration, in inches but less than 6 inches.

4. If during auger drilling, refusal is met, mention "Refusal at _____ feet." Do not indicate the type and nature of material in which refusal was met, unless additional boring was done or a sample otherwise obtained from this material.

5. Raw data from the field or laboratory test should not be included in the report; only final values and information required for design or construction should be provided.

TABLE 1: TERMS FOR RELATIVE DENSITY, CONSISTENCY AND FIRMESS OF SOILS

A. RELATIVE DENSITY OF COHESIONLESS SOILS		B. RELATIVE CONSISTENCY OF COHESIVE SOILS		C. RELATIVE FIRMESS OF CEMENTED SOILS *	
N-VALUE	TERM	N-VALUE	TERM	N-VALUE	TERM
0-4	Very Loose	0-2	Very Soft	0-4	Very Soft
5-10	Loose	3-4	Soft	5-8	Soft
11-30	Medium Dense	5-8	Medium Stiff	9-15	Moderately Firm
31-50	Dense	9-15	Stiff	16-30	Firm
> 50	Very Dense	15-30	Very Stiff	31-50	Very Firm
		30-60	Hard	> 50	Hard
		> 60	Very Hard		

* Provided by Sergent, Hauskins & Beckwith, Phoenix, Arizona.

TABLE 2: SCALE OF RELATIVE ROCK WEATHERING

Designation	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 inch into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

TABLE 3: SCALE OF RELATIVE ROCK HARDNESS

Term	Field Identification
Extremely Soft	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.
Very Soft	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife. Scratched with finger nail.
Soft	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.
Medium Hard	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.
Hard	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.
Very Hard	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.

TABLE 4: STRATIFICATION TERMS

Term	Characteristics
Laminations	Thin beds (< 1/2 inch)
Fissile	Tendency to break along laminations
Parting	Tendency to break parallel to bedding, any scale
Foliation	Non-depositional, e.g., segregation and layering of minerals in metamorphic rocks

TABLE 5: JOINT AND BEDDING SPACING TERMS

Spacing	Joint Spacing Terms	Bedding/Foliation Spacing Terms
Less than 2 in.	Very close	Very thin (laminated)
2 in. - 1 ft.	Close	Thin
1 ft. - 3 ft.	Moderately close	Medium
2 ft. - 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick (massive)